METHOD FOR HANDLING OF TRANSITION OUT OF PAGING CHANNEL USER EQUIPMENT (PCH UE) STATES IN UNIVERSAL MOBILE TELECOMMUNICATION SYSTEM (UMTS)

FIELD OF THE INVENTION

This invention generally relates to handling of UE states in wireless communications and more particularly to a method of handling of transition out of paging channel UE states in UMTS.

BACKGROUND OF THE INVENTION

The following table of abbreviations is intended to assist in an understanding of the invention:

3GPP	3rd Generation Partnership Project
CCCH	Common Control Channel
C-RNTI	Cell Radio Network Temporary Identifier
DCCH	Dedicated Control Channel
DTCH	Dedicated Traffic Channel
FACH	Forward Access Channel
FDD	frequency-division duplex
MAC	Medium Access Control
PCH	Paging Channel
RACH	Random Access Channel

RRC	Radio Resource Control
TDD	time-division duplex
TDSCDMA	time-division synchronous code-division multiple access
UE	User Equipment
UMTS	Universal Mobile Telecommunication System
U-RNTI	UTRAN Radio Network Temporary Identifier
URA	UTRAN registration area
UTRA	Universal Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network

In the 3rd Generation Partnership Project (3GPP) protocol specifications for Radio Resource Control, there are four possible states in the Universal terrestrial radio access (UTRA) RRC Connected mode (see Figure 1). These states allow the UTRAN to allocate resources to the User Equipment (UE) on a demand-basis. The UE is put into the CELL_PCH/ URA_PCH state by the UTRAN depending on the traffic activity originating from the UE.

At the access stratum level, the UE is identified either by

a) U-RNTI

b) C-RNTI

While using the common transport channels (e.g., RACH, FACH, PCH), UTRAN recognizes the UE using one of the above identifiers. C-RNTI gets deleted while entering the CELL_PCH or URA_PCH state. It also gets deleted when UE reselects a cell (even in a CELL_FACH state).

Whenever the UE transitions from CELL_PCH/ URA_PCH state to CELL_FACH state, it performs the Cell Update/ URA Update procedure. Also, if the UE does not have a valid C-RNTI in the CELL_FACH state, it needs to get one from the UTRAN via the Cell Update Procedure. UE transmits the CELL UPDATE or URA UPDATE message on the common control channel (CCCH). The CELL UPDATE CONFIRM can come either on CCCH or DCCH. Figure 2 shows the successful Cell Update scenarios, including the basic flow without a response from the UE, and with a response from the UE. Refer to standard 3GPP TS 25.331: Radio Resource Control (RRC) Protocol Specification. At the higher level, URA Update procedure is also similar.

All the connected mode UE state transitions, except coming out of CELL_PCH/ URA_PCH, are UTRAN directed (i.e. UTRAN orders UE to be come into the indicated state). On the other hand, UE has to come out of CELL_PCH/ URA_PCH state, depending on the events occurring at the UE. As stated above, these transitions always take place via either Cell Update or URA Update procedure. The applicable standard specifications (including 3GPP TS 25.331: Radio Resource Control (RRC) Protocol Specification, and 3GPP 25.321: Medium Access Control (MAC) Protocol Specification) state that the UE enters CELL_FACH state just when the Cell Update/URA Update procedure starts. This is intended because the CELL UPDATE CONFIRM/ URA UPDATE CONFIRM message may come on the DCCH, which is unavailable in the CELL_PCH/ URA_PCH state. However it may be noted that at this point, the UE does not

have a C-RNTI.

The UE also does not have a C-RNTI if it reselects a cell in the CELL_FACH state.

For mapping the DCCH/DTCH logical channels over RACH (transport channel for uplink), UE MAC uses the C-RNTI in MAC data PDU header (see standard 3GPP 25.321: Medium Access Control (MAC) Protocol Specification). As a result, the DCCH/DTCH transmission over RACH is not feasible unless the UE has a C-RNTI. On the other hand, UTRAN can send downlink DCCH/DTCH messages over FACH, by using the U-RNTI in the MAC data PDU header. Hence the UE can only have a half duplex downlink link for DCCH/DTCH until it has a C-RNTI again.

The problems identified in standard 3GPP TS 25.331: Radio Resource Control (RRC) Protocol Specification are:

1. UE behavior while Cell Update is in progress (CELL_FACH without C-RNTI): UE in CELL_FACH state but without a C-RNTI, has only a half duplex (downlink) DCCH. As a result, the UE will not be able to transmit 'Initial Direct Transfer' or 'Uplink Direct Transfer' (refer to standard 3GPP TS 25.331: Radio Resource Control (RRC) Protocol Specification for details) if it has just entered the CELL_FACH state to initiate the Cell Update procedure. However according to standard 3GPP TS 25.331: Radio Resource Control (RRC) Protocol Specification, the UE is required to delay the direct transfer procedures (until cell/ URA update completes)

only if they start in the CELL_PCH/ URA_PCH states. No such restriction is mentioned for the CELL_FACH state. This discrepancy is illustrated in figure 3, which shows CELL_FACH without C-RNTI. A number of such scenarios are possible because the UE non-access stratum has two independent state machines for circuit-switched (CS) and packet-switched (PS) services. Both of these utilize the common RRC connection or in other words the common RRC state.

2. Multiple (Sequential) Cell/URA Updates: The high priority cell/URA updates get delayed due to UE's transitioning to CELL_FACH (without C-RNTI) state. For example, if the UE initiates a periodical cell update in the CELL_PCH state, and then it detects uplink data to transmit, it may not send a cell update with this high priority cause (uplink data transmission), until it has possibly returned to the CELL_PCH state again. This scenario is illustrated in figure 4, showing the high priority cell update getting delayed.

It is desirable, considering the issues in the known arrangements, to provide an efficient method of handling of transition out of CELL_PCH/URA_PCH UE states in the UMTS.

SUMMARY OF THE INVENTION

The invention addresses the prior art issue stated hereinabove by clearly identifying that the CELL_FACH state has actually two sub-states for the UE.

The UE can be with C-RNTI, or the UE can be without C-RNTI. The invention considers the two UE sub-states so as to specify the correct UE behavior in the CELL_FACH state. As described hereinafter, the invention is applicable to layer 3 of TDD, FDD and TDSCDMA as relating to UMTS systems, but the invention is envisaged to be applicable to other scenarios as well.

BRIEF DESCRIPTION OF THE DRAWING

A more detailed understanding of the invention may be had from the following description of a preferred embodiment, given by way of example and to be understood in conjunction with the accompanying drawing wherein:

Figure 1 is an illustration of RRC states and state transitions including GSM;

Figure 2 exemplary cell update procedure of two types, the basic, and that with a response from the UE;

Figure 3 is an illustration of a CELL_FACH without C-RNTI;

Figure 4 is an illustration where high priority cell update gets delayed; and,

Figure 5 is an illustration of a preferred embodiment of a modified UE state machine.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

The description that follows is directed to a preferred embodiment, which identifies that the CELL_FACH sate has actually two sub-states for the UE. As

described hereinafter, the two sub-states include the following two sub-states for UE:

i) UE without C-RNTI. UE has only half duplex DCCH/DTCH capability in the downlink direction.

ii) UE with C-RNTI. UE has the full duplex DCCH/DTCH capability.

The invention includes two solutions in the form of two alternatives to specify the correct UE behavior in CELL_FACH state:

a) Clearly identify the sub-states within CELL_FACH. We will refer to CELL_FACH without C-RNTI as HALF_CELL_FACH for the sake of illustration (see Figure 5). The UE transitions from CELL_PCH/ URA_PCH state to CELL_FACH state only via HALF_CELL_FACH state. Also the UE enters the HALF_CELL_FACH from CELL_FACH state in case of cell reselection. The UE remains in the HALF_CELL_FACH state as long as the Cell Update/ URA Update procedure is active. The cell/ URA update triggers applicable to CELL_PCH/ URA_PCH (e.g. uplink data transmission) also apply to the HALF_CELL_FACH state.

b) Modify the text for all RRC procedures requiring uplink DCCH/DTCH transmission, to delay the procedure until the cell/ URA update is completed. Also enhance the cell/URA update procedure to make it possible for UE to send the cell update with the high priority cause (e.g. uplink data transmission), if the UE is without a C-RNTI.

The foregoing is a description of a method of handling UE states in UMTS, and offers several advantages including the following:

1. The UE behavior will be clearly defined in terms of its transmission/ reception capabilities. This would potentially avoid a lot of un-necessary signaling between UE and UTRAN.
2. Cell Update/URA Update procedure will be speeded up because of the correct recognition of events in terms of UE transmission capabilities.

While this invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention as described hereinabove.